CTEN Non Destructive Assay of LANL Transuranic Waste Drums

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Abstract

Active neutron measurements were conducted on two lightly loaded transuranic (TRU) waste drums using the Combined Thermal/Epithermal Neutron (CTEN) non-destructive assay (NDA) system. Assay results were statistically the same as that measured on WIPP certified NDA systems. All requirements for the deployment (as defined by DOE/AL) were met and requirements needed to meet WIPP certification were identified.

1. Introduction

The Combined Thermal/Epithermal Neutron (CTEN) non-destructive assay (NDA) system was designed to assay transuranic (TRU) waste by employing either (or both) an active neutron interrogation or a passive spontaneous neutron measurement. The even-mass plutonium isotopes (^{238}Pu, ^{240}Pu, and ^{242}Pu) spontaneously emit neutrons, which are passively detected by the CTEN detectors. In the active mode, the CTEN pulses the waste drum using a 14 MeV Zetatron neutron generator, which causes fissile isotopes (*e.g.*, ^{239}Pu, ^{235}U, etc.) to emit neutrons that are subsequently detected and quantified.

2. Objective of this Assay

There were a number of objectives for measuring TRU waste drums in the CTEN assay system before the formal certification process was completed. One was to demonstrate that all nuclear facility requirements had been satisfied. Secondly, the assay waste drums using the CTEN would confirm that all requirements for deployment as defined by DOE/AL had been satisfied and that the system was ready to begin WIPP certification. Thirdly, it was desired to show that CTEN would provide meaningful assay results. Finally, it was desired to identify issues that will require further work before the CTEN system can be used to assay waste destined for the WIPP site.

3. Waste Assay on CTEN

The CTEN NDA system underwent an Unreviewed Safety Question (USQ) determination for the system installation and checkout[1] and subsequently for waste operations in the RANT nuclear facility at TA54. Both USQs screened negative and

[1] USQD-TA-54-38-00-89, Installation of the Combined Thermal/Epithermal Neutron (CTEN), April 25, 2000

subsequently the CTEN operating procedure was approved[2]. Management approval for the waste assay was given on January 3, 2001 and the waste drum measurements were made the following day.

The two waste drums used in the assay were drums for which acceptable knowledge was available (Table 1) and which had also been assayed on the High Efficiency Neutron Counter (HENC), an NDA neutron assay system certified for WIPP.

Table 1. Waste Characterization From Acceptable Knowledge

Drum ID	Waste Stream	Pu Mass (g)
52148	TA-55-19	2.7
54473	TA-55-19	0.6

The two TRU waste drums were assayed on CTEN on January 4 and January 8, 2001 using a preliminary calibration done in September 2000. The calibration is considered preliminary since it was based on only three replicate measurements of a three-gram standard, PDP 1-3.0, and did not include a full range of calibration standards as will be required for WIPP certification. The software used for the waste drum assay was the same software that LANL Group NIS-6 is in process of submitting to the TWCP quality assurance office (estimated date of submittal: January 12, 2001). The CTEN data presented is for an active measurement. The passive mode installation and checkout revealed a number of problems with the signal channels that were corrected subsequent to the preliminary calibration and so are not included in this report.

The CTEN active mode assay applied 20000 Zetatron neutron pulses to each drum and required a total of 3 minutes of assay time per drum. The HENC assay results for drum 52148 required 30 minutes using the Add-A-Source matrix correction mode while drum 54473 required 4 hours of assay time using the truncated multiplicity mode. The results are shown in Table 2.

Table 2. CTEN Assay Results and Comparison With Certified HENC System

Drum ID	CTEN Assay Pu Mass (g)	HENC Assay Pu Mass (g)
52148	1.369 ± 0.690	1.185 ± 0.125
54473	0.179 ± 0.095	0.294 ± 0.014
54473 (CTEN Replicate)	0.160 ± 0.086	

[2] TWCP-DTP-1.2-061, R.0, "Waste Assay System Using the Combined Thermal Epithermal Neutron (CTEN) System, January 5, 2001.

The CTEN and HENC assay results are statistically identical.[3] The replicate comparison is also statistically identical. These data are summarized in Table 3.

Table 3. Comparison of CTEN/HENC Means and CTEN Replicate

Drum	52148	54473	54473	54473
Assay Technique	CTEN	CTEN	CTEN	CTEN
Comments				Replicate
Pu Mass (g)	1.369	0.179	0.16	0.179
Pu Mass Error (1s)	0.690	0.095	0.086	0.095
Assay Technique	HENC	HENC	HENC	CTEN
Pu Mass (g)	1.185	0.294	0.294	0.16
Pu Mass Error (1s)	0.125	0.014	0.014	0.086
Assay Same or Different?	Same	Same	Same	Same

4. Deployment

On November 21, 2000, the Department of Energy's Albuquerque Operations Office (Pamela Saxman, Branch Chief) defined the requirements for deployment of the CTEN system as: installation in the operations facility and completion of two assays of TRU waste drums destined for WIPP. This does not mean that CTEN is WIPP Certified, only that it has been installed, has run assays of real waste to document that it produces useful information, and that the operations group has accepted the instrument and is pursuing WIPP certification for routine operations as defined in the Appendix. The assay runs documented above demonstrates that these requirements have been met and that that the CTEN should be considered deployed on January 12, 2001

5. Conclusions

The CTEN system has been approved for waste operations within the nuclear facility at RANT and, therefore, is considered deployed. Future WIPP certification issues to be performed by the end-user are described in the Appendix.

Preliminary calibration effort was completed and applied to the assay of two waste drums. The resulting CTEN active measurements produced results statistically the same as another neutron NDA system certified to WIPP requirements

[3] Two-tailed tests for sample means, applying two standard deviations for the error bars.

APPENDIX

CTEN Certification Issues

There are several issues that must be addressed before CTEN becomes WIPP certified, and these are summarized in this appendix. These are the responsibility of the end-user.

Calibration

The calibration of CTEN is part of the installation and checkout and remains to be completed. This will include calibration using appropriate NIST traceable standards, waste matrix correction, development of system check methods (probably using Cf252 and depleted uranium sources), and validation to a range of plutonium mass standards ranging from 0.1 to 160 grams. The assay times for passive measurements also needs to be verified (currently, 300 seconds is used).

Procedures for calibration, system checks, and validation

The procedures for calibration, system checks, and validation will be written. This step will be performed along with the calibration step above since the methods developed during testing will affect the final procedure. Final approval of the procedure will require TWCP program office and WIPP CAO approval.

Complete Software Quality Assurance (SQA)

Complete the requirements documentation and Installation and Checkout (in process). Also will need to submit to QA the design documentation, implementation documentation, verification and validation documentation, user's manuals, etc. as required by TWCP-QP-1.1-006.

Procedures for data reporting

The batch data reporting requirements will need to be developed, including the appropriate forms to be used. The total measurement uncertainty will be determined. The procedure will require TWCP program office and WIPP CAO approval.

Development of approach for handling large quantities of data

The current WIN-CTEN program generates many files containing copious data and these should be consolidated into a single manageable file (probably an ASCII file)

containing only the requisite data that will permit recreation of the reported data while satisfying the QA requirements of the TWCP program.

Data standardization with other systems

The current CTEN-FIT active and passive visual basic applications (VBA) modules do not meet the current WIPP data reporting requirements. Specific applications that provide assay reports similar to those developed for HENC will need to be prepared.

Final hardware configuration for operations

The CTEN system was setup for ease of conducting the installation and checkout requirements. Recent electrical safety concerns (assessed as easy to correct) have been identified that must be corrected prior to further operations. During the recent system checks for this waste measurement effort, either a detector bank or amplifier section was found to be inoperative; this must be corrected prior to undertaking the passive calibration effort.

Interference with HENC Assays

Preliminary investigation shows that the HENC system will detect the Zetatron pulses during a CTEN active measurement. It's uncertain what the implications are at this time. The data suggests that possibly only the precision of an active background or active measurement will be affected, but the effect must be quantified and assessed. Alternatively, a procedure will be required that prevents simultaneous active CTEN operations while HENC measurements are in process. At this time, the latter procedure has been implemented.

System Applicability

System applicability for waste streams assayed will need to be developed. This will matrix corrections as a function of drum loadings (metals, sludge, empty, etc.). The preliminary data shown here suggests that for lightly loaded drums, the CTEN can provide useful data in minutes whereas passive systems may take hours to generate.